

## **Modeling Circulation along the Vietnamese Coast Influenced by Monsoon Variability in Meteorology, River Discharge and Interactions with the Vietnamese East Sea**

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Award Number: N00014-12-1-0323

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### **LONG-TERM GOALS**

An overarching goal of the project team is the development of robust ocean modeling systems suited to exploring interactions between submesoscale circulation on continental shelves and mesoscale variability in the adjacent deep ocean. Processes of interest include: wind-driven coastal currents and related upwelling and downwelling; the dispersal of river source waters; the dynamics of exchange processes at the shelf-break; optical signatures associated with sediments, terrestrial runoff, and local biological productivity; and, vertical mixing and stratification.

A key aspect of the modeling systems we develop is the use of advanced variational methods for the assimilation of satellite and in situ observations to achieve improved state estimation and subsequent forecast skill in real-time applications.

A further objective of project team members is sustaining the Regional Ocean Modeling System (ROMS) international community User Portal ([www.myroms.org](http://www.myroms.org)) to provide tutorials, documentation, and user support for ROMS users worldwide. This effort promotes adoption by the broader international ocean modeling community of the capabilities developed and/or demonstrated in projects such as this.

### **OBJECTIVES**

Our specific objective for this project is to develop and apply an ocean modeling system suited to exploring the interconnectedness of submesoscale coastal dynamics on the southern Vietnam continental shelf with mesoscale variability in the Vietnamese East Sea (VES). Processes of particular interest include: monsoon-driven coastal currents (both wind and buoyancy forced); identifying the source waters for upwelling that drive primary production on the shelf; dispersal of the Mekong River source waters; the optical signature of fine sediments carried by the Mekong; and stratification and mixed layer variability.

<b>Report Documentation Page</b>			Form Approved OMB No. 0704-0188	
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1. REPORT DATE <b>2012</b>	2. REPORT TYPE <b>N/A</b>	3. DATES COVERED <b>-</b>		
<b>4. TITLE AND SUBTITLE</b> <b>Modeling Circulation along the Vietnamese Coast Influenced by Monsoon Variability in Meteorology, River Discharge and Interactions with the Vietnamese East Sea</b>			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
<b>6. AUTHOR(S)</b>			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> <b>Institute of Marine and Coastal Sciences Rutgers, The State University of New Jersey 71 Dudley Road New Brunswick, NJ 08901</b>			8. PERFORMING ORGANIZATION REPORT NUMBER	
			10. SPONSOR/MONITOR'S ACRONYM(S)	
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b>			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
			12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>	
13. SUPPLEMENTARY NOTES				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>SAR</b>	18. NUMBER OF PAGES <b>3</b>
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>	19a. NAME OF RESPONSIBLE PERSON	

## APPROACH

A circulation model of the VES using the Regional Ocean Modeling System (ROMS) with Incremental Strong Constraint 4-Dimensional Variational (IS4DVAR) data assimilation will represent mean, seasonal, and mesoscale variability, with an emphasis on contrasting conditions during the different phases of the monsoon but including the capability to represent typhoon forcing.

Two-way nesting of high-resolution coastal and deep ocean domains will be developed to accurately represent the interaction of the deep ocean and coastal dynamics, i.e. down-scaling and upscaling.

The modeling system we develop will be suited to subsequent implementation as an integrated predictive model for regional oceanographic studies.

The project will provide for instructing Vietnamese researchers and students on using, reconfiguring and enhancing ROMS for future studies.

The project team comprises researchers at three institutions: Rutgers University (J. Wilkin, J. Levin, H. Arango, J. Zavala-Garay), Woods Hole Oceanographic Institution (W. Zhang), and the University of Colorado (W. Han). The team responsibilities are:

- (i) Regional mesoscale dynamics of the VES: W. Han, J. Levin, H. Arango
- (ii) Dispersal and across-shelf transport of river plumes on continental shelves: W. Zhang, J. Wilkin
- (iii) 4DVar data assimilation of altimetry and SST in mesoscale and shelf regimes: J. Zavala-Garay, J. Levin
- (iv) ROMS nested and 2-way coupled grids: H. Arango
- (v) Point of contact and liaison with Vietnamese collaborators: J. Wilkin, J. Levin

## WORK COMPLETED

Activities during this initial partial year of the project centered on assembling the required input data and making choices on the configuration of the regional VES model. Details on the domain for the nested/downscaled shelf model will follow in year 2.

## RESULTS

The project team reached consensus on several key aspects of the configuration of the VES regional model. To simulate VES dynamics the open boundaries of the domain perimeter will be placed well east of the Luzon Strait because transport variability there preconditions mesoscale circulation in the eastern VES/South China Sea. Though shallow, a mean flow through the Taiwan Strait must also be imposed from an external, larger domain model. Building on experience in the PHILEX DRI experiment and conversations with colleagues (J. Doyle) at NRL on potential synergies with our project, we propose regional NCOM output as a promising basin-scale analysis within which to nest our regional data assimilative ROMS model. These boundary values will be adjusted as part of the control variables of the data assimilation.

Inspecting NODC archives of in situ CTD profiles in the VES we find a surprisingly dense sampling of the central VES along shipping routes from Singapore to Japan, and coastal Vietnam. Over 17,500 profiles exist in the archive. We have established collaboration with Vietnamese colleagues to augment this archive with other data to build a climatology suited to initialization, and bias control, in the data assimilative analysis.

Our involvement in NASA's Ocean Surface Topography Science Team has introduced us to reprocessed versions of Jason-1 and Jason-2 altimeter SST from CTOH/Toulouse using regional range corrections and along-track filtering to recover data within 3 km of the coast. This region is notoriously cloudy, but in the Middle Atlantic Bight we have evaluated microwave satellite radiometer data (which are unaffected by cloud) blended with high resolution infrared imagery and found this a useful data set for assimilation. These remotely sensed sea surface height (SSH) and temperature (SST) data sets will comprise the data to be assimilated in our mesoscale analysis system. Historical in situ observations, and new observations acquired through the field component of this DRI, will be used as independent validation and skill assessment.

## **IMPACT/APPLICATIONS**

The modeling system we are developing under this project will extend our experience with 4D-VAR data assimilation in mesoscale boundary current regimes. Our experience to date is with energetic western boundary current regimes (the East Australian Current) and less energetic marginal shelf regimes (the Middle Atlantic Bight). The VES has greater similarities to the MAB but with significantly stronger local forcing in regard to river sources (Mekong River) and meteorology (monsoon). This places the circulation in a different dynamical regime and enriches the spectrum of experience with ROMS-IS4DVAR.

## **RELATED PROJECTS**

None.